NUTRITIONAL QUALITY AND ACCEPTABILITY CHARACTERISTICS OF COMMON BEANS (*Phaseolus vulgaris* L.): A SELECTION OF UNSOLVED PROBLEMS

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Preface

Since 1960, at least three books have been published having a structure and intention similar to the present work. The structure used is simply a way to approach the problem stepwise, from the description of the problem itself, to those requirements involved in solving the problem. The first book was financed through a grant from Public Health Services, U. S. Department of Health, Education and Welfare and edited by Jack E. Mckee et al., 100 Problems in Environmental Health*. The second, 101 Problems in Food Science and Technology**, was edited by C. O. Chichester et al. and supported by the same governmental office. The last, with the support of the National Academy of Science and the National Research Council, edited by E. R. Pariser et al., is Food Science in Developing Countries: A Selection of Unsolved Problems***. The present work, prepared in the Bean Nutrition and Quality Laboratory of the Bean Program at the Centro Internacional de Agricultura Tropical (CIAT), titled Nutritional

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* Jones Composition Co. & Kirby Lithograph Co., 1961. 185 pp.

** U. S. Department of Health, Education, and Welfare, n.p., 1962. 192 pp.

*** National Academy of Sciences. National Research Council, 1974. 79 pp.

Quality and Acceptability Characteristics of Common Beans (Phaseolus vulgaris L.): A Selection of Unsolved Problems, has as its main objective to stimulate the interest of research workers, familiar with these and similar problems, in solving the problem. The list of problems considered is not extensive, but is an attempt to include the major research areas where in-depth study is scarce or lacking. The problems discussed are:

1. Water absorption restrictions: The "hard-shell" or "hard-seed" phenomenon.
2. Digestibility of starches.
3. The problem of flatulence.
4. Protein digestibility.
5. Overall protein quality.
6. The "hard-to-cook" phenomenon.
7. General composition data base.
8. Antiphysiological factors.
9. Relationships between consumer acceptability criteria and laboratory screening techniques.

1. WATER ABSORPTION RESTRICTIONS: "HARD-SHELL" OR "HARD SEED" PHENOMENON

Problem Description

Soaking beans before cooking is a widely spread cultural pattern. A short survey in Colombia (van Harpen, 1983) showed that close to 50% of the urban population surveyed in two cities (Cali and Medellín) consider this practice as important as the parameters for buying beans.

To a certain extent, soaking is important in reducing some antiphysiological substances and in decreasing the amount of energy needed for cooking beans, since the cooking time required to obtain the accepted texture for consumption is reduced after soaking. The data collected indicates that these are two different phenomenon. The so called hard-to-cook phenomenon will be considered later in detail. "Hard-shell" or "hard-seeds" (HS) describe mature dry bean seeds that fail to absorb water after being soaked for a reasonable period of time. "Semi-hard-seeds" (SHS) have been defined as seeds which do not fully imbibe water during the first 24 hours of soaking. These are important factors determining rejection of a variety by the consumer and also by the breeder, since seed hardness is responsible for reduced or delayed germination. This phenomenon is found not only in stored seeds but also in fresh grains and is indicative of the effect of varietal differences. The core of the HS and SHS problems is to discover the reasons for existing varietal differences determining susceptibility or resistance to be hard-seeded after storage. Another important point to be clarified is the environmental effect on this phenomenon.

Background Information

Inadequate water uptake may determine insufficient heat transfer, required to inactivate antinutritional factors. The result is poor quality beans due to limited chemical reactions such as protein denaturation and starch gelatinization. The seed coat and specifically the outer portion which is a waxy cuticle is the first effective barrier to water absorption.

There is much controversy on the routes followed in water imbibition. Four structures have been proposed as possible sites for water entry: the hilum, the micropyle, the raphe, and the whole seed coat. Kile and Randall (1963) concluded that the mycropylar orifice in some varieties is the main site for water to enter the seed; while the hilum and the raphe seemed to be important in other varieties. From the experience at CIAT, the role of the seed coat's orifices (hilum, raphe and micropyle) is important but quantifying specific differences is very difficult because of the intrinsic varietal variability in these and orifices and because the seed coat itself is permeable to water.

The seed evaluated absorbed significantly less water when the orifices were covered, but differences in water imbibition varied among materials. Therefore, it is practically impossible to generalize on the exact amount of water entering through each orifice. Defa-Dedeh and

Stanley (1979) demonstrated that the physical parameters used in a trial with cowpeas explain a significant part of the imbibition. Lareo (1986) found similar results in common beans.

These results imply that there are some structural differences at the level of the testa between soft and hard seed. Watson (1948) concluded that no structural features of the testa could be identified in impermeable seeds that were not also present in permeable seeds. Wassimi et al. (1981) suggest and Wyatt (1977) demonstrated that HS may be associated with testa color, but results presented in Table 2 are not in agreement with their conclusions. There is no clear evidence of the presence of different structures in permeable and impermeable seeds of P. vulgaris, but significant differences in water absorption between shiny and opaque seeds have been fully demonstrated (CIAT, 1986). The main difference in the seed's testa of these two types of grains is the presence of a waxy layer in shiny materials. Other differences have been found in other legume seeds; these have been reported by Werker et al. (1979) for Pisum spp. Several works report differences between soaked and unsoaked beans (Varriano-Marston and Jackson, 1981), but no published reports are available on differences of varietal origin in the HS structures.

Excellent background information on the heredity of HS is found in Lebedett's works (Lebedett, 1943). From findings with other legumes, mineral nutrition (Wassimi et al, 1978), and overall soil fertility levels (Bagoury, 1975) affect HS formation.

The effect of environmental conditions, particularly during storage, has been studied throughout history (Gloyer, 1932; Hincks and Stanley, 1986). The mechanism whereby hardening develops in stored beans has recently been explained by Stanley's liquification hypothesis (Hincks and Stanley, 1986), but more comprehensive studies including genetic variabilities are needed.

Current knowledge seems to indicate that the SHS phenomenon is more the result of environmental conditions than a varietal factor. Seeds with less than 8% moisture exhibiting SHS do not show this characteristic if moisture content is kept higher than 10% (Holubowics et al., 1987). However, Dickson and Boettger (1982) report that inheritance of SHS involves several genes; they found other genetic characteristics also related to this phenomenon.

Possible Approaches to a Solution

A possible approach would involve studies on near-isogenic lines present in both permeable and impermeable type seeds. These seed types are being studied at CIAT's breeding program for the introduction of the I gene for resistance to the Bean Common Mosaic Virus (BCMV). Some near-isogenic lines susceptible or resistant to BCMV show significant differences in their water absorption kinetics and in the total amount of water imbibed. The susceptible materials exhibited a permeable-like behavior and the isogenic resistant materials showed the HS phenomenon, in some cases extreme. Study the structural differences in this material's testa will bring light upon the HS and SHS phenomena from a structural point of view. From the environmental point of view, the new techniques for accelerated development of hardening will be useful in studying and understanding this aspect of the problem. These studies will need to be done hand-in-hand with field studies on the effect of environmental conditions. Other genetic approaches will involve the use of near-isogenic lines but with shiny- and opaque-seed lines. These type of materials are being developed by CIAT's breeding program.

Special Requirements

From the structural point of view, the most important requirement is the capacity to process and study a large number of samples with electronic microscope technology; the possibility of breeding for isogenic materials is useful, but can be accomplished by other programs or institutions. The group or institution involved with environmental studies will require field capacity under changing climatic conditions as well as laboratory equipment to develop accelerated hard seeds for storage under normal conditions.

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2. DIGESTIBILITY OF BEAN STARCHES

Problem Description

Digestibility of bean starches, low when compared to that of cereals or tuberous starches, is an important factor affecting both bean nutritional quality and consumer acceptability. From the nutritional point of view, low digestibility inhibits full utilization of the energetic potential of beans. From the acceptability point of view, low digestibility of starches is apparently associated with poor cooking quality.

An important factor limiting the determination of starch content is the difficulty in the methodology for extraction and quantification. Extraction of nondisintegrated granules is important for studying the physico-chemical and functional properties, and accurate and precise quantification methods are required in determining digestibility rates. Both aspects are closely related. The panorama has become more complicated with the recent finding that the in vitro rate of hydrolysis does not predict the in vivo metabolic response. In addition to these basic problems, more knowledge is needed with respect to a) differences in total starch content and composition among varieties, b) environmental effects on content and composition, and c) variations in these parameters in relation to the plant's degree of maturation.

Background Information

Knowledge on digestibility and, in general, on the nutritional value of bean starches, is still fragmentary. Starch is the most abundant bean carbohydrate and content varies from 28 to 58% (Reddy et al, 1984). The variations observed are due to differences in cultivars and analytical procedures. One of the most systematic methods to study bean starches was developed by Biliaderis et al. (1979). They found that bean starches have a high molecular weight (2×10^6), a high degree of polymerization (1000), and an elevated viscosity (130 ml/g).

Relatively few studies have been carried out on in vitro digestibility, mainly because of the uncertainty of the relationship with in vivo digestibility. Most of studies are based on the amount of maltose released per a determined bean weight after amylolisis during a specified period of time, using amylases obtained from different sources. Fleming & Vose (1979) studied the in vivo digestibilities of raw and cooked beans in experiments with rats and did not find mayor differences. There has been much controversy on the methods used; in fact, Abbas et al. (1987) reported higher digestibilities after soaking and cooking, while Savitri et al. (1987) indicated that germination affects digestibility. Apparently the analytical procedure used is one of the mayor sources of differences encountered. O'Dea & Wong (1983) found that legumes that are rapidly digested in vitro give rise to proportionately greater metabolic responses in vivo than legumes having a slow in vitro digestibility. Menezes & Lajolo (1987) found that in the bean itself, the amylase inhibitor reduces starch digestion. Hoover et al. (1985) report rather unclear relationships among functional properties (i.e., swelling power, solubility, gelatinization temperature, hot paste viscosities) and the enzymatic digestibility of different bean biotypes. Wong et al. (1985) indicated that digestibilities were more dependant on the structural and molecular organization of the granular constituents.

Possible Approaches to a Solution

Solutions in this area will come only gradually, mainly because of the lack of a basic understanding of the problem. One of the first steps would be to conduct varietal variability studies, which would enable determining the representativeness of typical materials. This would include studies not only on starch content, but also of fraction composition, and the in vivo and in vitro digestibilities. If granule structure, size, or any other parameter were identified for groups of biotypes, studies on development, maturity, and processes could be carried out with a small number of typical materials. In vivo studies could be developed using a very simple methodology: evaluation of blood glucose levels over different periods of time after ingestion of bean samples, using standardized animals (rats) or humans. The working hypothesis for this approach is the finding that the rate of hydrolysis is associated with the blood glucose level, and that the first is affected by several parameters as was discussed previously. This methodology would indicate total bioavailability of the bean sample starches.

Special Requirements

The main requirement in working with starches or, in general, with carbohydrates, is a laboratory with complete analytical facilities to make separations, characterizations, and quantifications by the TLC, PC, GLC, and HPLC methods, for example, and having the equipment required in conducting functional studies, such as the Brabender amylograph, viscosimeters, etc. All these together with the biochemical facilities for in vitro studies and an animal colony for in vivo studies. Even though it is expensive and difficult to manage, an infrastructure is required for human studies, to confirm the in vitro and in vivo studies. A multiple source of materials (germplasm bank) and area on which to grow trials are also needed for the genetic, development, and variability studies.

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3. THE PROBLEM OF FLATULENCE

Problem Description

Ingestion of beans is known to cause flatulence in humans and animals. This discomforting effect is one of the main barriers limiting acceptability of beans as a source of protein, especially in new markets, that is, in communities where bean consumption has not been a habit. Flatus in the intestinal tract results in abdominal rumblings, cramps, pain, and, in extreme cases, diarrhea. A factor making quantification of the flatulence problem difficult is the difference in responses in terms of flatus generation among different persons and particularly among different communities. Apparently, there is a physiological adaptation of the intestinal flora in consumers of large amounts of beans, which does not happen in sporadical consumers or in communities where bean ingestion is not a habit. The oligosaccharides of the raffinose family of sugars (raffinose, stachyose, and verbascose) found in beans have been identified as one of the important contributors to flatus in humans and experimental animals (Cristofaro et al., 1973; Murphy et al., 1972).

Background Information

The varying amounts of raffinose oligosaccharides may be responsible for the different degrees of flatulence. Stachyose content represents at least 50.0% of total sugars in beans, but ranges from 0.2 to 4% of the dry matter, and total sugars constitute from 0.3 to 6.0% of the dry matter (Reddy et al., 1984). Microflora in the intestinal tract metabolizes these oligosaccharides, producing large amounts of carbon dioxide and hydrogen during the process (Olson et al., 1981.).

Several methods have been employed to measure flatus in humans and animals. Calloway et al. (1966) and Calloway and Murphy (1968) suggested an easy and useful method for measuring flatulence in humans. This method involved the analysis of breath samples for the presence of hydrogen and methane. Their theory was based on the assumption that most of the hydrogen and methane produced in the intestine diffuses into the intestinal lumen and blood and passes to the lungs, from where it is released in the air expired. Additional methods were developed by Gumbmann & Williams (1971) and Levitt & Ingelfinger (1968).

Other studies indicate that, even after removal of oligosaccharides, dry beans can still induce flatus (Hellendoorn, 1976, 1979). The degree to which various beans and bean products produce flatulence in humans varies considerably among subjects. When the basal diet without beans produces flatus at a range that runs from 0 to 28 ml/h, the experimental diet with 146 grams of navy beans produces flatus at a rate ranging from 5 to 465 ml/h (Steggerda et al., 1966).

Possible Approaches to a Solution

Various approaches have been suggested to a solve the problem of flatulence; the most promising is genetic manipulation to obtain varieties low in raffinose . All the other solutions known are of a technical nature, such as that of removing the oligosaccharides by soaking. Murphy, 1973, studied the possibility of eliminating the flatulence effect by genetic selection. An in-depth study of varietal differences is required to further develop this theory.

Special Requirements

A very complete analytical laboratory is required to work with carbohydrates; this should have TLC, PC, GIC and HPLC facilities as the source of broad genetic variability. Facilities are also required to work with animals or humans in order to study the degree of flatus production of the different materials.

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4. PROTEIN DIGESTIBILITY

Problem Description

All evidence reported has concluded that legume grains are a major source of protein which could potentially be of higher quality. However, the reasons for the relatively low digestibility of proteins are not completely known, although several factors such as the antiphysiological (tannins) characteristics, the molecular structure of the protein itself, and the relationships with other nutrients have often been suggested to cause low protein digestibility.

Several studies have found apparent protein digestibility of Phaseolus vulgaris to have great variation within the same species. Less variation has been found for the in vitro values. Bressani and Alias (1977) state that heat-treatment decreases protein digestibility, while Carnovale (1987) reports increments of at least 10% between raw and cooked in vitro digestibilities. Recently, problems encountered in the methodology used led to confusion on the data collected. Animal assays are complicated and time consuming, in vitro results were found to not reflect exact animal behavior, and microbiological studies usually do not reflect differences in requirements and metabolic rate of higher organisms.

Background Information

Knowledge on protein digestibility is extense but scattered. Some protein fractions (i.e., globulin E) have been found to be resistant to in vitro digestion by pepsin, papain, and trypsin even after denaturation with heat (Seidl, Jaffé and Jaffé, 1969). Rosalis (1972) found a protein fraction which was not soluble in water and had less than 0.60% digestibility. A purified globulin fraction has a true digestibility of 28.10% in comparison to 88.82% for casein. In the case of this globulin, the low value is clearly due to its molecular structure since its digestibility increases three-fold to 90.90% once denatured by heat (Levy-Benshimal and García, 1986).

In relation to the anti-nutritional factors, the low protein digestibility is attributed to the amounts of tannins and other polyphenols present in the seed coat (Elías et al., 1979). The high level of chemical interaction between tannins and proteins reduces the protein's active sites for the enzymatic in vitro hydrolysis or in vivo hydrolysis in the gastrointestinal system. Tannins also react with the digestive enzymes, thus interfering their reaction with dietary proteins. These combined effects on dietary proteins and digestive enzymes result in low digestibility. The low digestibilities in the case of wild cultivars is due to the presence of the trypsin inhibitors (Rackis and McGhee, 1975). It was suggested that lectins influenced the activity of digestive enzymes (Thompson et al., 1986). Germination and cooking in other legumes were reported to improve in vitro protein digestibility (Satwardhar et al., 1981). The relationship of protein digestibility with the carbohydrate fractions was basically predicted by Bressani (1977) when he postulated differences in heat resistance among the cell wall, starch, and sugar fractions. If these fractions are not broken apart by the effect of by heat, the proteins are only partially liberated and not "available" for enzymatic hydrolysis. Some studies have shown beans consumed together with their broth have lower digestibilities than when they are consumed alone (Braham and Bussani, 1985).

Possible Approaches to a Solution

The main problems in bean digestibility studies are related to the methodologies used for measuring and processing the sample and to the genetic variability. The ultimate step recommended to confirm digestibility findings is human studies. Temporary changes of blood aminoacids after food ingestion seems to be one of the best systems in studying these effects. The high cost of this method is the major constraint. The studies recommended would seek first to find a chemical or biochemical screening test that reflects animal behavior, followed by validation of important data with animals (perhaps rats), and finally, confirmation of findings with humans.

Special Requirements

The basic needs for digestibility studies include a source of variability in beans, a chemical laboratory with aminoacid determination methods, and the potential for conducting human studies. The animal colony is desirable in any of the cases, as the final stage in chemical studies or the first in human studies.

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5. OVERALL PROTEIN QUALITY

Problem Description

Common beans constitute the main source of supplementary protein in cereal and starch food diets of large segments of the Latin American and African populations. Protein content in beans averages 24%, with a range from 17 to 36%. It is common knowledge that the deficiency of sulphur aminoacids is one of the most important factors limiting nutritional quality and the main factor with respect to the overall quality of the proteins, which in turn affects the biological value of bean seed proteins. The main reasons have not been fully understood. Part of the explanation is found in the composition of the sulphur aminoacids themselves, but another apparently important factor is the relationships of these aminoacids with the protein fraction. The combined effect of these factors is a reduced bioavailability of these aminoacids. One associated problem is the determination, with acceptable methodologies of the aminoacids present and their bioavailability.

Background Information

The main problem encountered in determining each of the aminoacids present is the considerable loss during acid hydrolysis, unless special precautions are taken. Microbiological assays for methionine used by Kelly (1971a, 1971b) provide a relative value using one bean sample as the constant internal standard. Chemical determination and bioavailability estimation need to be carefully studied in collaborative efforts to standardize methods. Kelly (1971b) reports that commercial cultivars, regardless of the seed source, tend to have relatively uniform levels of available methionine, but sufficient variation exists within species to allow for improvement through hybridization and selection. Gepts and Bliss (1984) report that phaseolin is a major source of available methionine in common beans. Adams (1972) found negative significant correlations between protein and cystine and methionine contents. Cystine-methionine content of bean proteins is improved at the lower levels of proteins.

Possible Approaches to a Solution

The main avenue of research to solve the sulphur aminoacid problem in beans is to start with a reliable screening methodology for both the total content (sulphur content perhaps) and the bioavailability. The most suitable method for the latter is perhaps the in vivo method which reflects all the interactions that affect it. Simultaneously, genetic studies are mandatory to detect variability through breeding or biotechnology of the genes that control the peptides found in abundance in these aminoacids. The relationships between protein content and these aminoacids needed to be documented also.

Special Requirements

Basically, laboratory facilities are needed for genetic and biochemical protein and aminoacid studies, with the potential to advance to biotechnology methods. Area should be available for field breeding, for maintaining the animal colony, and for conducting human studies as the final process in screening and validation studies.

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6. THE HARD-TO-COOK PHENOMENON

Problem Description

The so-called hard-to-cook phenomenon, due to varietal traits or developed after storage, is one of the main consumer acceptability criteria. Long cooking periods needed to obtain an acceptable eating texture imply high energy costs and reduction in the biological value because of the reduction of the bioavailability of some aminoacids. Marked varietal differences were found even among fresh materials. Varietal differences among stored materials are reflected in the fact that not all varieties increase the cooking time at the same rate or by the same amount during a determined period of time. Environmental factors also have an important effect on the hard-to-cook phenomenon.

Background Information

Several factors are involved in the hard-to-cook phenomenon. Varriano- Marston and Jackson (1981) report structural changes during development of cooking hardness in stored grains. According to Rockland et al. (1974), the middle lamella softens during cooking, thus permitting the separation of adjacent cells; divalent cations are involved in this process. Mattson (1946) reported that cooking ability was related to the content of phytic acid and calcium. The Guelph University's team, with the leadership of D. Stanley, have participated in the IDRC Bean Network with intensive studies on the liquification process as an explanation to the hard-to-cook phenomenon (IDRC, 1985; IDRC, 1987; IDRC, 1988). The Michigan State University group working on this topic has found important genotypic and environmental effects represented in cultivar x location or genotype x season variances (Hosfield et al., 1984; Ghaderi, 1984; Hosfield and Vebersax, 1980). However, some materials show stable behavior across seasons and environments. Several methods for evaluating this phenomenon have been developed, but the Mattson bean cooker and the textural characteristics process seem to be the most convenient (Lareo et al., 1987).

Possible Approaches to a Solution

CIAT has concluding data on the varietal differences among fresh beans in terms of the hard-to-cook phenomenon; a simple method was recently developed to predict the resistance or susceptibility of grains to become hard to cook after storage. Knowledge on textural and structural changes associated with the broad genotypic variability will complement these studies, to open the way for future in-depth studies on environmental effects with the object of selecting stable materials to be used in breeding programs.

Special Requirements

Of mayor importance during the first stage, is a source of broad variability, the possibility of developing accelerated cooking hardness, and facilities for textural and structural studies. The second stage would require the feasibility of producing materials in environments with different conditions, and sufficient area to conduct breeding trials.

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7. GENERAL COMPOSITION DATA BASE

Problem Description

Lack of knowledge on the composition of beans from all the different environments, genotypes, and other several parameters is a major constraint to research in this field. Breeding efforts demand a good source of data for the selection of possible parents in a specific study. Nutritional studies require working with a broad range of possibilities for increasing or detecting a specific group of materials. Current knowledge is based on a few commercial varieties or promising lines but broad-base information on all the important nutrients and factors is an urgent need.

Background Information

This area is both big and small. Big for specific cases and small for the generality of the bean world. Perhaps the closest to a "philosophy" on data collections is the INFOODS program of the UN (Rand and Young, 1983), including the principal variability source and the methodological resource for highly reliable and precise analysis for most nutrients.

Possible Approaches to a Solution

A strong collaborative project among various participants is required, which has access to materials from a broad variability source of genetic and environmental patterns. Each institution would be responsible for a number of specific nutrients or data.

Special Requirements

Laboratory facilities having access to a broad genetic source of variability for studying all important nutrients is mandatory, without implying that they coexist in the same geographical region.

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8. ANTIPHYSIOLOGICAL FACTORS

Problem Description

Beans are a source of some heat-labile and heat-resistant antiphysiological factors. Among the first group, the most important are the proteolytic enzyme inhibitors and the lectins. In the second group, the most important compounds are the condensed tannins. In the case of the first group, the real interest is more academic than practical, however, if the breeding programs are able to reduce the cooking time, the evaluation of the heat-labile factors will be extremely important. Tannins in the second group pose a problem, especially when the grain is soaked and cooked, due to their capacity to interact and bind several nutrients, with the concomitant reduction in nutrient bioavailability.

Background Information

Highly significant differences in toxicity among cultivars due to lectin content have been reported (Jaffé et al., 1972). A trypsin inhibitor has been obtained from beans (Wagner and y Riehm, 1967). Its concentration varies widely with the variety. Other proteins, different from the trypsin inhibitor, were observed to interfere with the activity of other proteases (Seide et al., 1969). An amylase inhibitor is present in most kidney beans (Jaffé and Vega, 1968) but can be destroyed by proper heating. The tannins related with protein digestibility interfere in two ways by interacting with the dietary proteins and with the digestive proteolytic enzymes (Elias et al., 1979) as well as with the iron, starches, and the other nutrients (Mehras et al., 1985). This interference has been found to be affected by genotypic differences (Lareo, 1988). This finding opens the possibility of controlling the problem through breeding techniques.

Possible Approaches to a Solution

The first step is accumulating knowledge on the actual varietal differences and the nutritional implications of each one of the factors, especially those that are heat resistant. These studies imply a source of genetic variability and the development of adequate methodologies for making both chemical and functional quantifications.

Special Requirements

The main need is a laboratory for both chemical and biological studies.

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9. RELATIONSHIPS BETWEEN CONSUMER ACCEPTABILITY CRITERIA AND LABORATORY SCREENING TECHNIQUES

Problem Description

It is a fact that texture of raw and cooked beans is an important attribute affecting acceptance; in some cases, texture may be more important than flavor. The logical studies pyramid has consumers at the pinpoint, panels specialist between consumers and laboratory technicians; in the third level is the laboratory that found the explanatory reasons for consumer acceptance which were quantified by the panel specialists; and the last top level has the screening laboratory that selected the material that met consumer preferences serves as feedback to all other levels of study, understanding, and selection. Therefore finding the adequate laboratory measurement for each consumer criteria is the core of the problem.

Background Information

Very few bean-specific studies have been developed in this area. With the only exception of in-depth studies conducted by Beverly Watts, from the University of Manitoba in the IDRC Bean Network (IDRC, 1985; 1987; 1988) and the preliminary studies conducted by D. van Harpen in CIAT's Bean Economics section. Both studies show the real feasibility of finding laboratory techniques that reflect the texture factors considered by consumers. There is still a big gap in the knowledge on flavor and cooking-related aspects.

Possible Approaches to a Solution

A strong interdisciplinary network is required to study current commercial varieties and the criteria for acceptance of these by consumers. The first step would be to establish references for the laboratory critical cutoff points for each textural and non-textural parameter. Methodologies need to be developed.

Special Requirements

Social groups of students for conducting surveys at all levels, a group of trained panelists for quantification of the criteria selected by the consumers, and texture and analytical laboratory facilities.

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